POLITÉCNICA

ASSESSMENT OF CONTENT OF TRITIUM, OTHER HYDROGEN ISOTOPES AND HELIUM IN A W ARMOR FOR AN EXPERIMENTAL HIPER CHAMBER

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Introduction

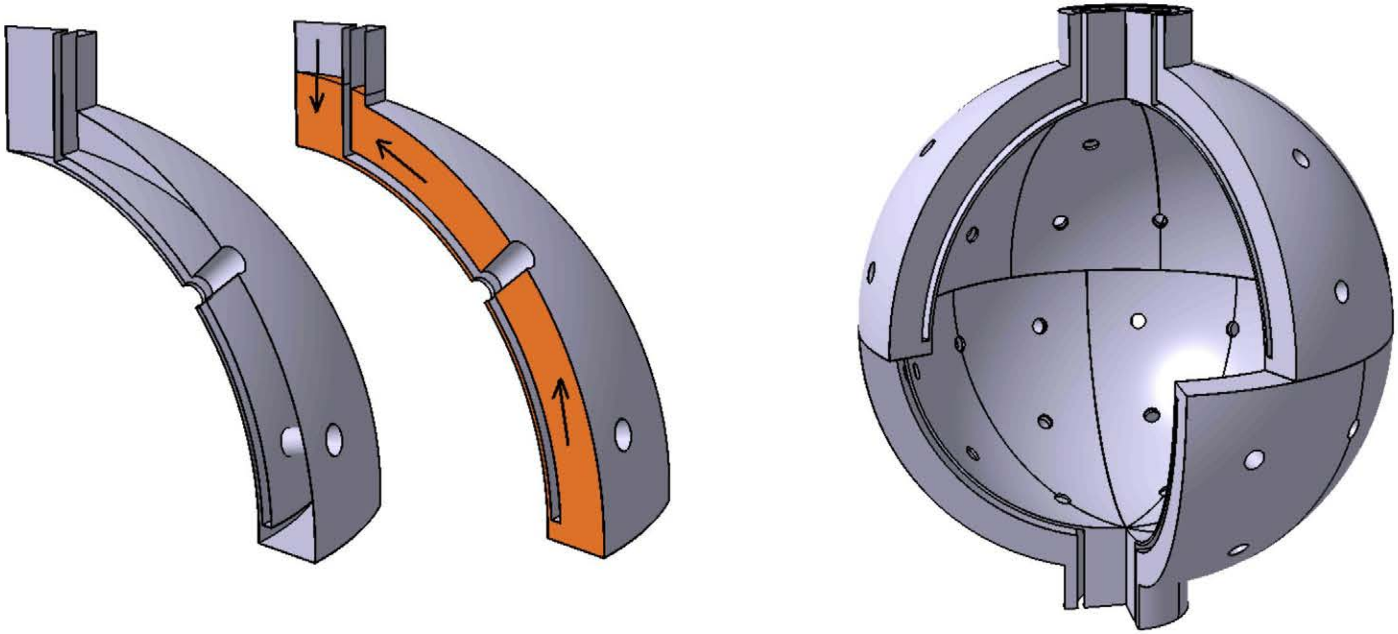
- Tritium breeding is an essential component of future fusion nuclear reactors.
- Nuclear fusion reactors require Kg quantities of tritium per year of operation.
- The principal source of tritium are CANDU reactors (21 in Canada, 4 in Korea, 2 in India, China, Rumania, Pakistan and Argentina)→ 1.8 Kg is recovered per year in total. **(50-100 M€/kg).**
- Stockpile remaining all over the world is estimated to be **27 Kg .**
- This will be sufficient to supply the ITER machine, which is not breeder, with tritium for 10 years of experiments.
- Tritium decays at 4.57% per year
- **A key system in a IFE Reactor (HiPER) is the TRITIUM BREEDING BLANKET and the TRITIUM PLANT (extraction, target manufacturing)**

Introduction: Tritium Plant

- **A good understanding and knowledge of tritium transport behavior and its parameters is a key issue for the Tritium Plant and the Breeding Blanket Units design.**
  - Tritium plant→ Tritium inventory

Introduction: Tritium Breeding Blanket

- The viability of DT fusion will depend on the capacity of management and breeding tritium with maximum eficiency.
- Well designed **Tritium Breeding Blanket:**
  - Breed enough tritium to replace what the fusion burns
  - Produce enough surplus every few years to fuel a new reactor



Introduction: Tritium Transport Parameters

- There is a need to assess **Tritium Transport Paramaters** for nuclear fusion materials due to the controversy that exists nowdays with some of them.
- Historical data for hydrogen isotopes solubility in LiPb → **controversy**

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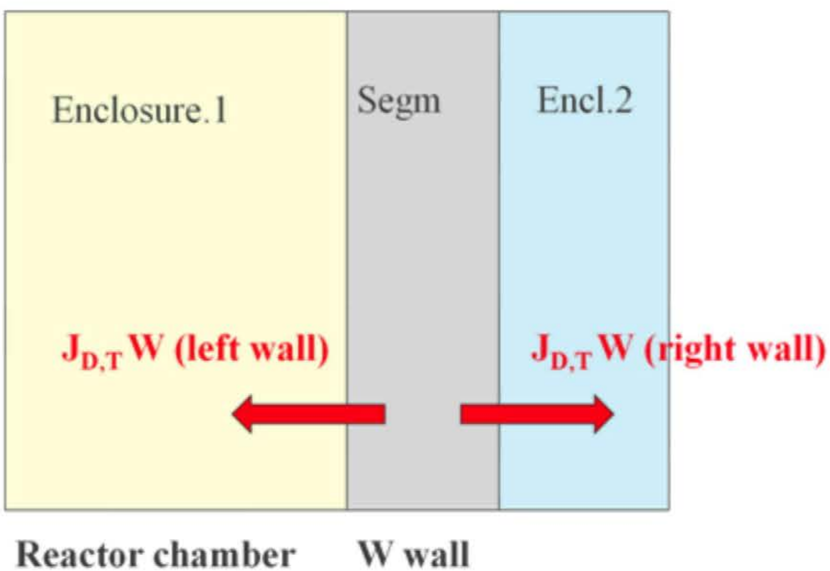
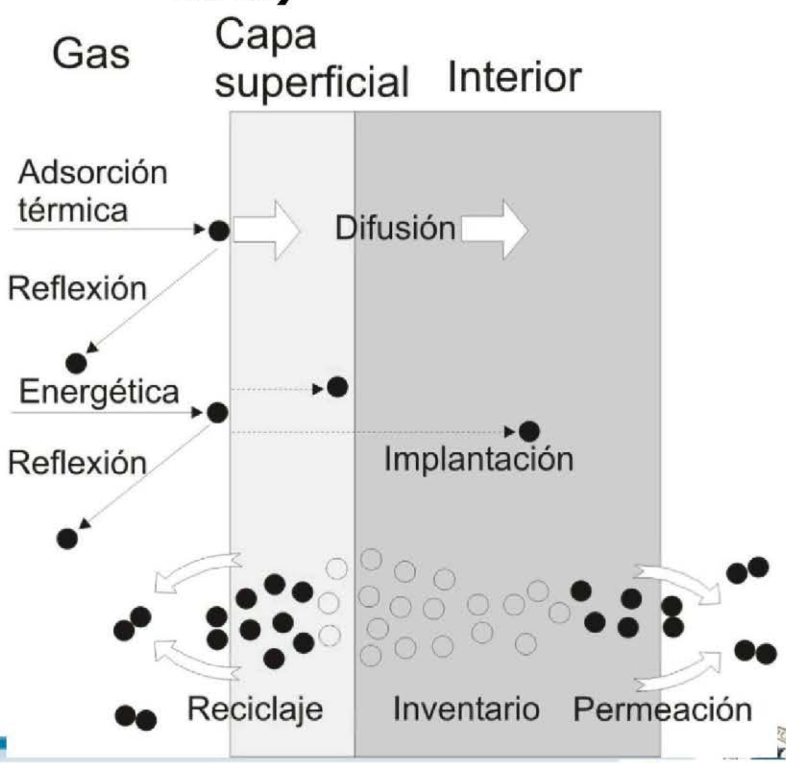
Case HiPER 4a

- H(D,T) INTERACTION WITH MATERIALS
- **Structures process:** Diffusion (concntration gradients, Soret effect) trapping.
- **Surface process**: adsorption, disociation, recombination and desorption
- **It is important to assess and know the principal parameters that determinate these process (D, Ks, Kr…)**

Block diagram showing HiPER Phase 4a representation on TMAP7:





Diffusion Simulation: TMAP7

- The TMAP Code was written at the Idaho National Engineering and Environmental Laboratory
- The code let introduce heat and mass sources and drains.
- Enclosures (Functional or Boundary) and Segments
- Traps

No traps has been taken in consideration in the simulations. But the coefficients that had been used in these simulations are experimental, so they had been calculated with traps in the tungsten.

LIMITATIONS

- There are limited and confused database on hydrogen isotopes transport parameters in W. Therefore, the same recombination and dissociation parameters have been used for H,D and T.
- Helium has been simulated independently with a different input, Helium does not has recombination/dissociation reactions in the surface
- TMAP7 is a 1D model

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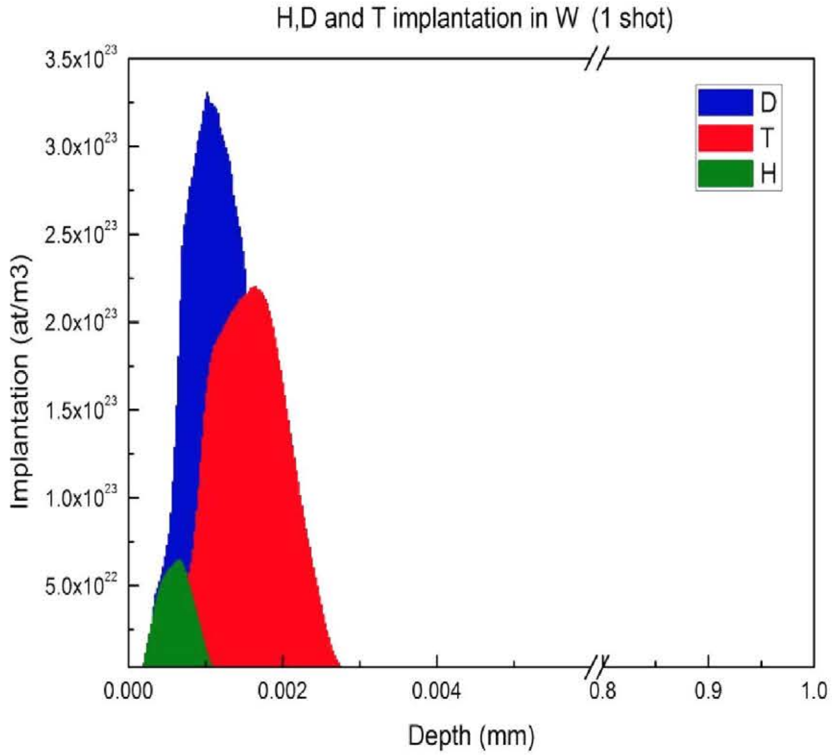
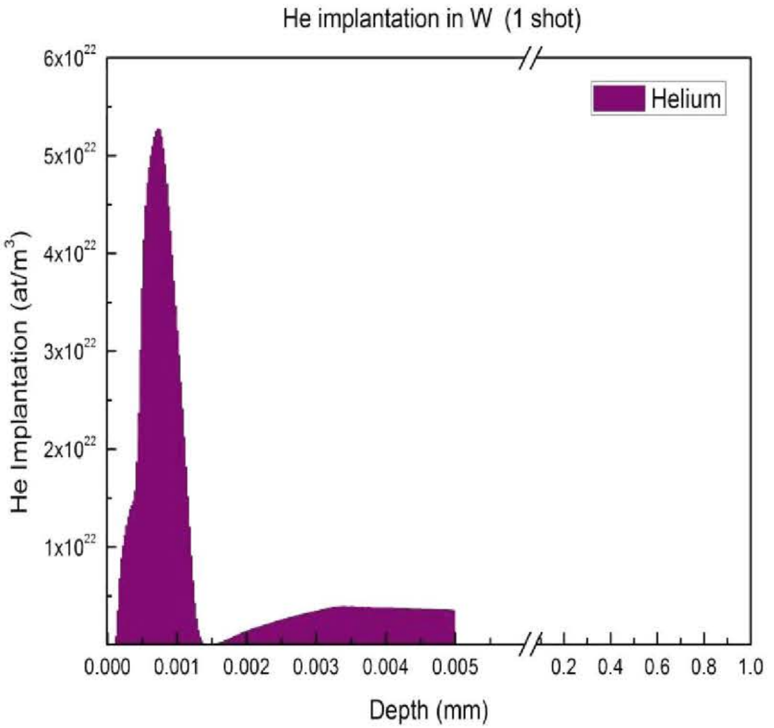
Results

Hydrogen isotopes Implantation inside a 1mm W wall after 1 shot

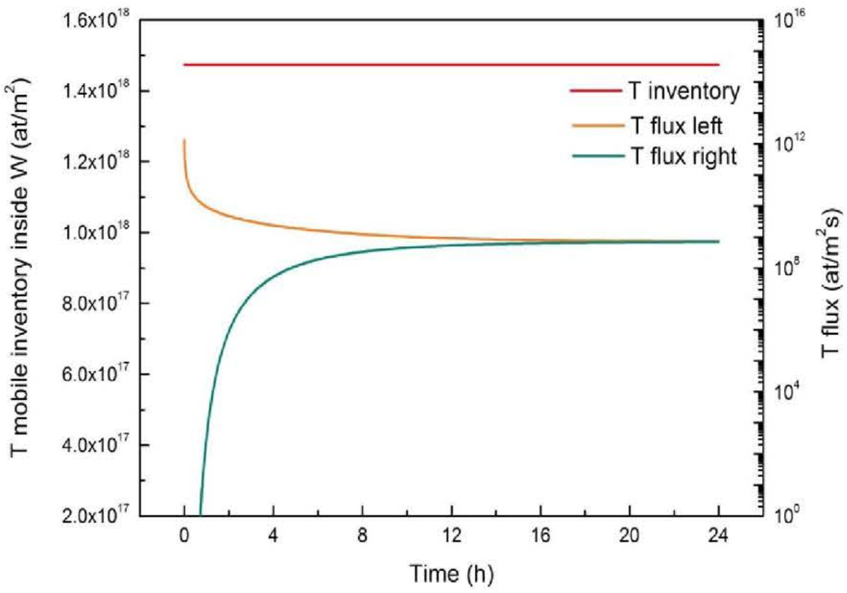


Helium Implantation inside a 1mm W wall after 1 shot

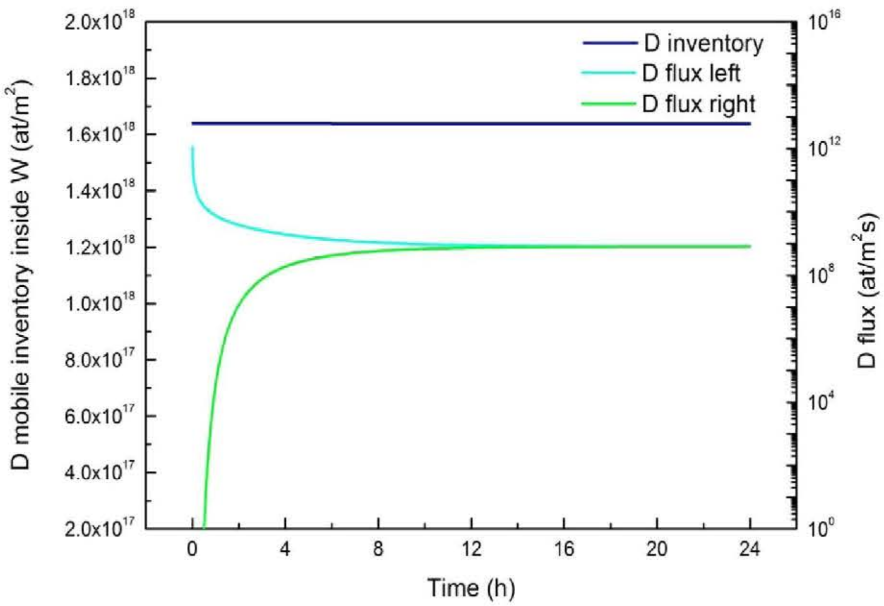


Results

Tritium mobile inventory inside W after 5 shots (in 10 seconds) during 24 hours.

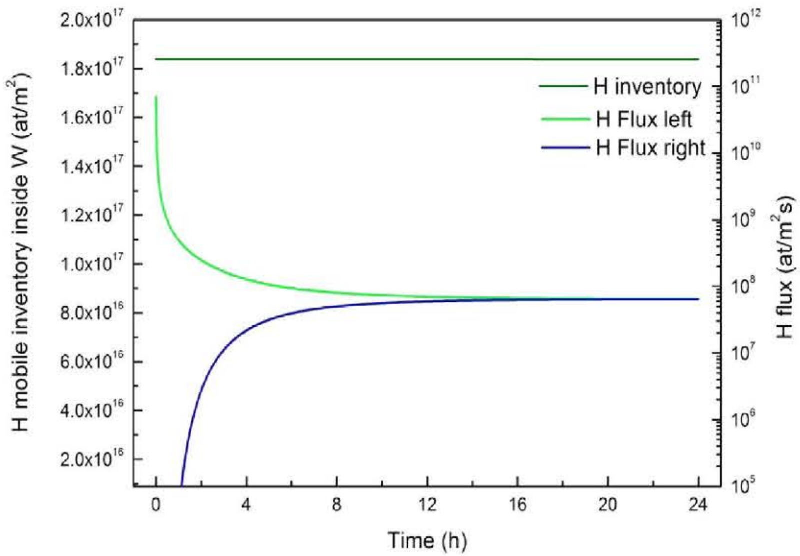


Deuterium mobile inventory inside W after
5 shots (in 10 seconds) during 24



Results

Hydrogen mobile inventory inside W after 5 shots (in 10 seconds) during 24 hours.



Hydrogen isotopes inventory, for HiPER 4a: almost all the isotopes stay inside W wall at T= 300K (desorption is negligible)

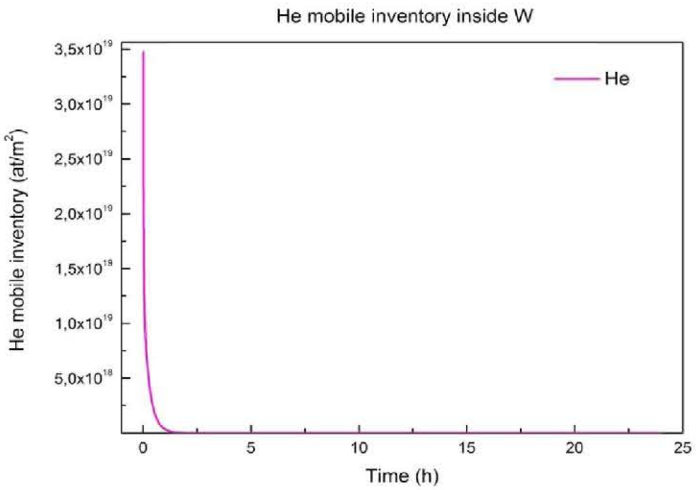
	Initial Part. (at/m^2)	Final Part. (at/m^2)	Total Flux left	Total Flux right
H	$1.8384 \cdot 10^{17}$ (100%)	$1.8381 \cdot 10^{17}$ (99.99%)	$4.6646 \cdot 10^{9}$ (0%)	$1.14937 \cdot 10^{9}$ (0%)
D	$1.6392 \cdot 10^{18}$ (100%)	$1.6387 \cdot 10^{18}$ (99.97%)	$6.9623 \cdot 10^{10}$ (0%)	$1.4016 \cdot 10^{10}$ (0%)
T	$1.4738 \cdot 10^{18}$ (100%)	$1.4732 \cdot 10^{18}$ (99.96%)	$8.0978 \cdot 10^{10}$	$1.0295 \cdot 10^{10}$ (0%)

Results

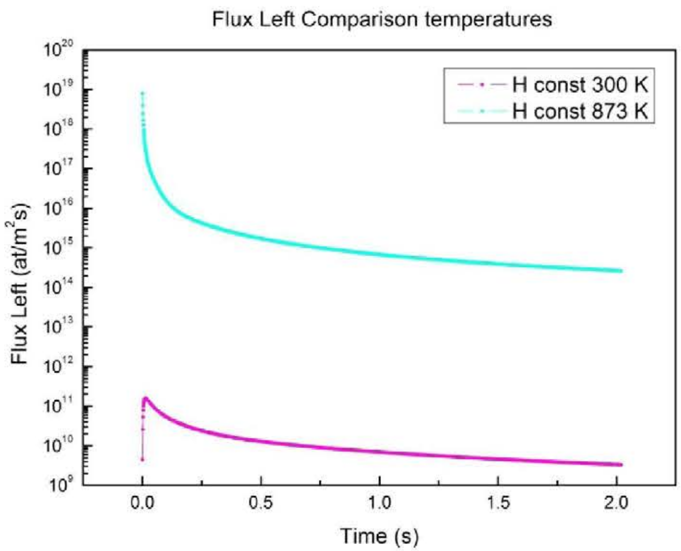
Helium mobile inventory inside W after 5 shots (in 10 seconds) during 24 hours.

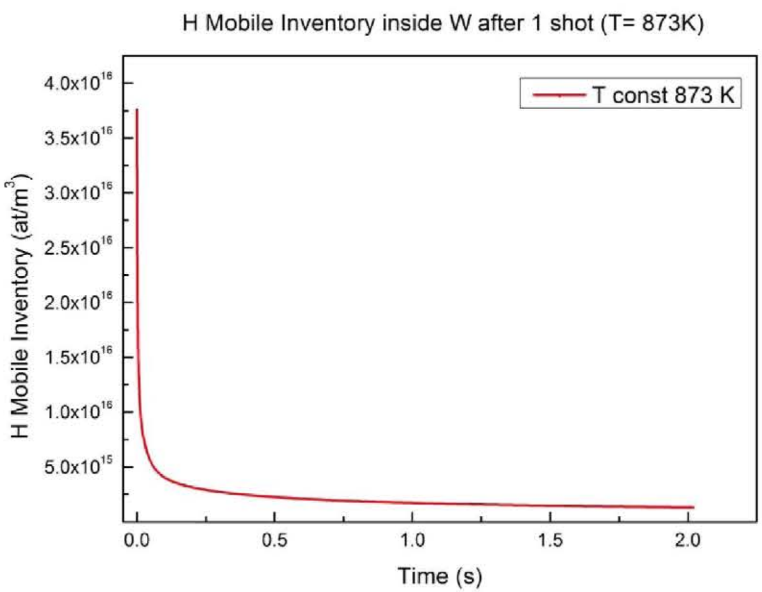
Almost all the Helium is released in about 2h

	Initial Part. (at/m^2)	Final Part. (at/m^2)
He	$3.47 \cdot 10^{19}$	0 (in 2h)



H Desorption comparison at T= 300K and T=873K → Desorption won't be negligible at T=873 K





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Conclusions and future plans

CONCLUSIONS

At HiPER 4a conditions (T=300K) the amount of particles released from the tungsten wall are negligible.

	Initial Part. (at/m^2)	Final Part. (at/m^2)	Total Flux left	Total Flux right
H	$1.8384 \cdot 10^{17}$ (100%)	$1.8381 \cdot 10^{17}$ (99.99%)	$4.6646 \cdot 10^{9}$ (0%)	$1.14937 \cdot 10^{9}$ (0%)
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FUTURE PLANS

In this study traps have not been calculated; in future investigations different traps must be studied for HiPER project and its working conditions.

A wall of steel or other structural material must be joint to the W wall. It is necessary to know the behavior of the different elements with the second wall.

THANK YOU VERY MUCH FOR YOUR ATTENTION

HiPER4a

NDITIONS FOR HiPER4a

100 shoots at 10 Hz with just 5 fusion explosions.

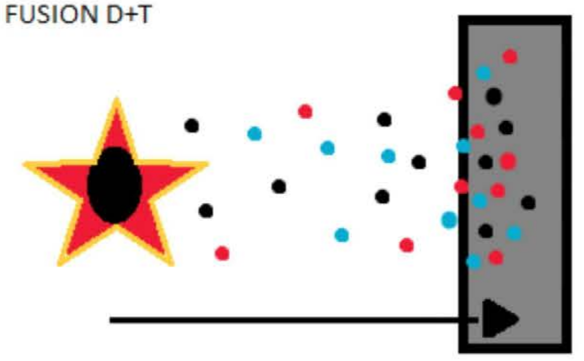
Light species yield of a 48 MJ shock ignition target which are transported and implanted in a 1 mm thick W wall.

Atoms energy: up some MeV

W temperature 300ºC after each shot. (room temperature)

No Coolant temperature.

Reactor chamber is under high vacuum conditions. (10^{-3} mbar)



MAIN PRODUCTS: D,T,He